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words, the principles of the development of ore deposits are the principles of the segregation of those elements which are of importance to man, but which, for the most part, are so rare that they are not included in the discussion in the chapter on the redistribution of chemical elements.

It is not possible in a summary to give any adequate idea of the scope of this treatise on metamorphism. A very broad range of facts, extending far beyond what might at first be regarded as a part of a treatise on metamorphism, is considered from the energy point of view. It is believed that the volume marks a great stride in the reduction of the entire subject of physical geology to order under the principles of physics and chemistry, and points out the way for a treatment of the entire subject from this point of view. K.

The Stone Reefs of Brazil, Their Geological and Geographical Relations, with a Chapter on the Coral Reefs. By JOHN CASPAR BRANNER. (Bulletin of the Museum of Comparative Zoölogy, Cambridge, Mass., 1904.) Pp. 285, 91 plates.

THIS contribution stands almost in a class by itself in that it adds a new variety to the recognized type-formations. While reefs of this class have not been wholly unknown to geologists, they seem to have been regarded rather as individual aberrancies than as expressions of a type dependent on regional conditions and prevalent within the range of those conditions. They have, indeed, been mentioned more or less frequently, but oftenest in such a way as to carry the suggestion that they were coral reefs or some modification of such reefs due to accessions of hardened sand. Their distinctive nature and its peculiarity was recognized by Darwin, Hartt, and a few others, but this comprehensive treatment by Dr. Branner is the first exposition that has brought forth their broader relations and their true significance; indeed, it is the first that has made clear the essential fact that they are not mere aberrant phenomena, due to a fortuitous combination of local conditions, but rather a type of formation, albeit a rare and regional one. While not confined to the coast of Brazil, these sandstone reefs are so limited and peculiar in their distribution, so far as present knowledge goes, as to give special interest to their localization. In the opinion of the author, this regional localization carries genetic significance, and the discussion of this forms a most interesting feature of the book. The peculiarities of these reefs are summarized by the author as follows:

I. They are of sand consolidated to a hard—in places almost quartzitic—sandstone.

II. They stand about flush with the water at high tide, while at low tide they are left exposed like long, low, flat-topped walls, with a width of from five meters to one hundred and fifty meters, and a length of from a few paces to several kilometers.

III. They accompany the shore-line with many and great interruptions from north of Ceará to Port Seguro, a distance of two thousand kilometers.

IV. With unimportant exceptions, the reefs do not occur along the Brazilian coast beyond these limits.

V. They usually stand across the mouths of streams and estuaries, forming perfect natural breakwaters for the small harbors behind them. Sometimes they follow the shore, either on the beach or at a short distance from it.

VI. They are all nearly straight. When crooked, their curves are gentle.

VII. The structure and position of the reefs and the animal remains they contain show that they have been made by the lithification of beach sands in place.

VIII. When stone and coral reefs occur together, the stone reefs are inside or landward of the coral reefs. It is possible, however, that there may be buried coral reefs in some cases to the landward of some of the stone reefs.

IX. The coral reefs are now growing over and upon the stone reefs in some places, while at other places there are stone reefs overlying dead coral reefs.

X. In general appearance, elevation, and position the sandstone reefs bear a striking resemblance to the coral reefs.

The characteristics of these reefs are set forth by careful detailed descriptions, unusually well illustrated by excellent sketches, cross-sections, outline maps, coast charts, and photographic plates (104 figures, 99 plates). The treatment also includes the discussion of several collateral themes, among which are the coast changes, concerning which the following conclusions are drawn:

1. There is no evidence of a perceptible change of level of the coast since the discovery of Brazil.

2. Changes have taken place in the form of the coast-line, and in the adjacent streams, bays, and estuaries in historic times, but they are all accounted for by the ordinary processes now in operation.

3. The stone reefs are not metamorphosed or folded, and they do not rise above tide-level, except in a few instances, where blocks have been tilted by the undermining done by the waves.

4. The coast lakes have been formed by the damming in of estuaries, by the sands blown along the coast, and by the throwing back into the estuaries of detritus cut by waves from adjoining headlands or brought down by streams from the land.

5. The straightness of the coast-line is due to the long period of wearing to which the coast has been subjected, and to the constant on-shore winds and waves along the coast.

6. During the dry season the waves of the sea are able to close the mouths of many of the weaker streams.

7. At such times only the large streams are able to keep their mouths boldly open.

8. Although no changes of level are known to have taken place within the historic period, there are evidences of both elevation and depression of the Brazilian coast in late geologic times.

9. The evidences of depression consist of:

a) The open bays: Rio de Janeiro and Bahia.

b) The partly choked up bays, such as Santos and Victoria.

c) The coast lakes formed by the closing of the mouths of estuaries, such as Lagoâ Manguaba, Lagoâ do Norte, Jiquiá, Sinimbu, etc.

d) Embayments altogether filled up.

e) The islands along the coast are nearly all close in-shore and have the appearance of having been formed by depression of the land.

f) The buried rock channels at Parahyba, now filled with mangrove swamps and mud, show a depression of at least twelve meters since those channels were cut.

g) Wind-bedded sand below tide-level on Fernando de Noronha.

10. The evidences of elevation consist of:

a) Elevated sea beaches, especially well shown about the Bay of Bahia, and along the coast of the state of Bahia.

b) Marine terraces about Ilheos in the state of Bahia. These are about eight meters above tide-level.

c) Horizontal lines of disintegration about one meter above high tide in granites and gneisses at and about Victoria, state of Espirito Santo.

d) Burrows of sea-urchins so far above low tide that sea-urchins cannot now live in them. These are well shown at Pedras Pretas on the coast of Pernambuco.

11. Of the two movements the depression has been much the greater and was the earlier.

12. The great depression probably took place in early Pliocene times (see chapter on Geology, pp. 8–33).

13. Following the Pliocene depression of the coast, the headlands were strongly eroded, the mouths of bays and estuaries were closed, and the coast line was straightened.

14. The standstone reefs of the coast were formed and hardened subsequent to the depression.

15. The coral reefs of the coast have helped build out the shores, and they have likewise protected the land from the destructive action of the waves.

16. The stone reefs have also protected the land, and have helped to prevent the encroachment of the sea.

17. The mangrove swamps have been important agents in building up the newly formed land about estuaries and embayments.

18. The sands of the coast are not of foreign origin, as has been surmised, but are derived from the adjoining headlands, or they have been brought down from the land by streams.

The discussion of the consolidation of the reefs and of the origin of the cementing material is very full and able, assembling and treating critically and judicially a wide range of data and of phenomena, with ample references to the literature of the subject. One of the most interesting points is the relation of the density of the sea-water to the deposition of calcium carbonate, and the genetic connection of the stone reefs with the density of the adjacent oceanic waters and with the surrounding climatic conditions. The conclusions relative to the consolidation of the reefs are as follows:

Stone reefs are formed where there are streams or lakes of fresh water entirely or partially restrained by the beach sands. The new reefs may be formed either in front of the old ones, or in the embayment and estuary behind the older ones. For similar reasons, stone reefs may form behind or landward of the coral reefs. This can only happen, however, in places where marine currents prevent the land-water from interfering with the growth of coral reefs.

The local lithification of the sea beaches is not uncommon, but the most noteworthy instances of lithification on a large scale are those of the northeast coast of Brazil and of the Levant.

The cementing material of the Brazilian stone reefs is chiefly lime carbonate.

The hardening of beach sands may be produced in the following ways:

1. By carbonated rain-water dissolving out the lime carbonate in the upper portions of calcareous sands and depositing it in the lower portions.

2. By the escape of carbon dioxide from the sea-water when the surf breaks upon the beaches.

3. By the escape of carbon dioxide from sea-water where it is warmed by the tropical sun.

4. By the submarine escape of carbon dioxide about volcanic vents.

These processes may have contributed somewhat to the hardening of the Brazilian reefs, but they do not seem competent to account for them altogether. These theories are especially incapable of accounting for the lithification of beaches behind older reefs.

The distribution of the consolidated beaches of northeast Brazil leads to the inference that the consolidation is directly related to the density of the sea-water. The geology and climatic conditions over the adjacent land are, however, important factors in the hardening of the reef sands. It seems probable that the consolidation of the reef sands would not take place if the rainfall were large enough and constant enough to keep the mouths of the streams open and the water of the streams fresh.

In a region of concentrated rainfall and long drouths the river mouths become temporarily closed, and the abundant aquatic and other life in the lagoons thus formed contributes to the organic acid of the waters which, upon penetrating the wall or dam of beach sand, first dissolves the lime, and then redeposits it when it comes in contact with the dense sea-water on the ocean side. In this manner some portions of the beaches have been hardened, while others have remained incoherent.

The density of the ocean water is in all probability considerably greater during the dry than during the rainy season, and this would still further hasten the consolidation of the beaches during dry seasons.

The process of beach-hardening is not a continuous one, but varies with geographic and climatic conditions. New reefs may be formed behind the older ones on the shores of the estuaries and embayments.

The monograph is closed by a chapter on the associated coral reefs.

T. C. C.

The Copper Deposits of the Encampment District of Wyoming. By ARTHUR C. SPENCER. (Professional Paper No. 25, 1904.) Pp. 107; 2 plates and 49 figures.

THE district of which Mr. Spencer treats in this report comprises some 450 square miles in southern Wyoming, so situated that the southern boundary of the area lies close to the Colorado line, while the one hundred and seventh meridian bisects it. The encampment district is crossed diagonally from southeast to northwest by the irregular line of the Continental divide, which is the crest of the Sierra Madre Mountains. The maximum elevation is 11,007 feet (Bridger Peak), and the minimum 6,650 feet.

The structure is essentially a low arch or anticline whose axis is parallel with the mountain crest, that is, east-west. The core of this arch is made up of a mass of hornblende schists and sedimentary rocks, closely folded and overturned to the north, the whole forming a complex east-west synclinorium. These rocks are said to be pre-Cambrian, though the reasons for this conclusion are not given. They were invaded at a later period by basic igneous rocks related to gabbros. The hornblende schists appear everywhere to be the basement upon which the sediments were laid down.

Flanking these pre-Cambrian rocks is a series of Mesozoic and Cenozoic sediments which are now confined to the southwestern part of the area, as a remnant of a great mantle of sediments that formerly covered the whole arch. These formations dip away to the south beneath the surrounding prairie. The oldest of these formations is the "Red Beds" series of the